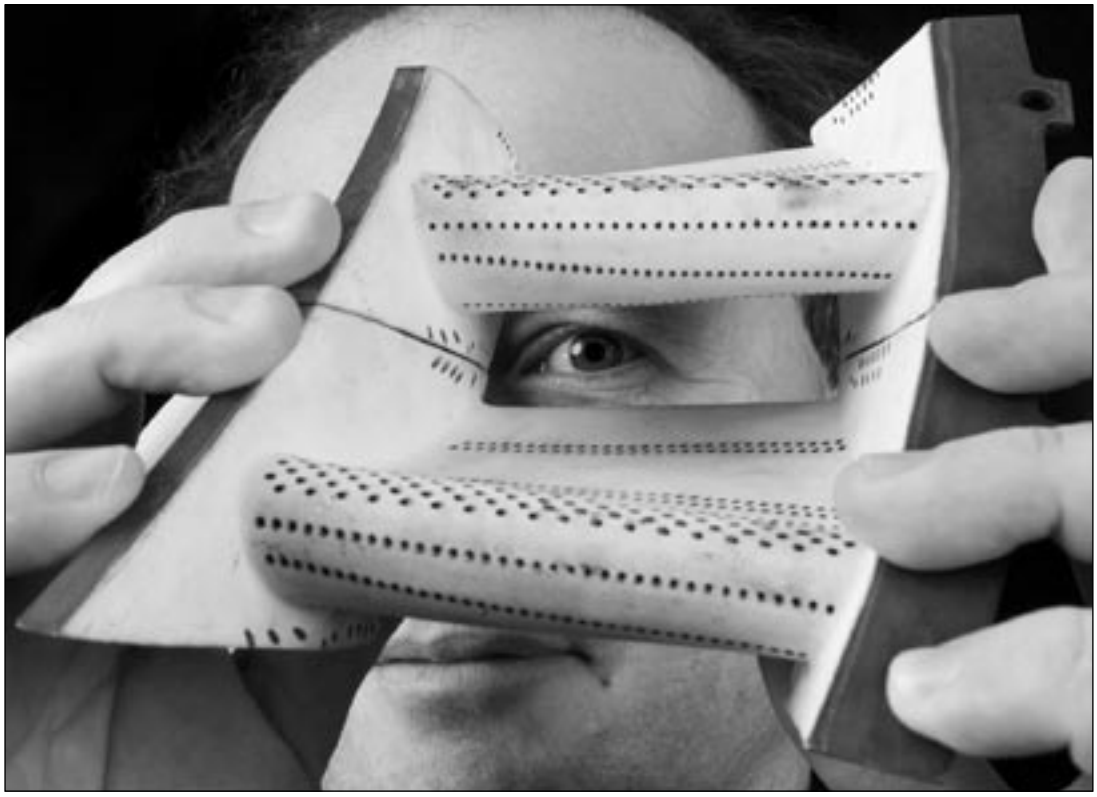
INSIDER

Newsletter for the Employees of Ames Laboratory ■ Volume 16, Number 3 ■ March 2005

Beating the Heat

A new bond coat may mean longer life for gas turbine engines

Flying from coast to coast or country to country has become a matter of routine for many people in today's fast-paced, workaday world. And frequent flyers have learned to take advantage of their valuable in-air time while jetting through the skies at 300-400 miles per hour. Some strategize delicate business maneuvers or scrutinize stock portfolios, while others mentally rehearse invited talks or happily succumb to the intrigue of a good novel. All this and more airline passengers can accomplish at 30,000 feet, compliments of the hardworking gas turbine engines that keep their carriers of choice in the "friendly skies."



With an eye to the future, Brian Gleeson is developing a new bond coat for thermal barrier coatings that will allow engine components, such as the turbine blade he is holding, operate more successfully in severe, high-temperature environments. Gleeson and co-principal investigator Dan Sordelet believe their basic research effort could mean greater reliability and longer lifetimes for gas turbine engines.

Not surprisingly, then, along with all the dependency on air travel that today's "commuter" has developed, there has come a steady demand for better, more efficient gas turbine engines that can operate at elevated temperatures. Addressing that need, Ames Laboratory and Iowa State University researchers have developed a new bond coat for thermal barrier coatings, or TBCs, that may allow gas turbine engines in aircraft and other power-generating technologies to better withstand severe, high-temperature environments. The basic research effort could provide a TBC system with significantly improved reliability and durability of turbine blades, thus enabling higher operating efficiencies and extending engine lifetimes.

Just what is a TBC?

Commercial thermal barrier coatings consist of three layers. The first layer is typically an aluminum-rich bond coat that is based on the compound nickel-aluminum, or NiAl. The bond coat is applied directly to the turbine blade. The second layer is a thin, thermally grown oxide, or TGO, which forms as the aluminum in the bond coat oxidizes. The third layer, a thin (around half a millimeter) ceramic top coat, has a low thermal conductivity *continued on page 4*

Long-time chemist Adolf Voigt dies

Adolf Frank Voigt, 91, emeritus professor of chemistry at Iowa State University, died Friday, March 11, at Green Hills Health Care Center.

Services will be at a later date. Burial will be in the ISU Cemetery. Adolf Voigt was born Jan. 31, 1914, in Upland, Calif., the son of Adolf and Marie Hirschler Voigt. He graduated from Pomona College, earned a master's degree from Claremont College and a Ph.D. in chemistry from the University of Michigan in 1941.

After teaching for a year at Smith College in Northampton, Mass., and marrying Mary London, he was hired to work on plutonium separation for the Manhattan project housed at ISU. At the end of World War II, he remained at ISU as a chemistry professor, teaching radiation and nuclear chemistry and establishing a research group.

He was assistant director of the reactor service and neutron fission research group at Ames Laboratory. He was instrumental in the planning and design of the research reactor at ISU, which was active from 1965 to 1978. He was also in charge of decommissioning the reactor and retired when that project was finished in 1981, having worked at ISU for 39 years.

His other interests included classical music and travel. He was an officer of the Town and Gown Chamber Music Association for a number of years, served in various capacities at Collegiate Presbyterian Church and traveled extensively. His last years were spent in quiet retirement at Green Hills Retirement Community. Memorials may be directed to Youth and Shelter Services, P.O. Box 1628, Ames, Iowa 50010.

Adolf Voigt (third from right) was one of the recipients of the 40-year service awards presented in 1984. Also pictured are, from left, Norman Carlson, Harry Svec, Velmer Fassel, Frank Spedding, Harley Wilhelm, Ray Fisher and David Peterson.

Note: Public Affairs only recently learned of the passing of two other long-time Ames Lab employees

John Richard

John J. Richard, 73, of Ames, died January 20 at Mary Greeley Medical Center in Ames following a very short battle with cancer. Funeral services were held Jan. 24 at St. Cecilia Catholic Church in Ames, and burial was in the Ames Municipal Cemetery.

John Richard

John J. Richard was born Nov. 30, 1931, in Dubuque, the son of Andrew and Marie (Hefel) Richard. He graduated from Loras Academy in Dubuque and completed a Bachelor of Science degree in chemistry from Loras College in Dubuque and a Master's degree from Iowa State University, while working full time as a research chemist at Ames Laboratory. He retired from the Lab after a 40-year career. Following retirement, he volunteered at Mary Greeley Medical Center, Meals on Wheels, Story County Conservation and St. Cecilia Church.

Harvey Burkholder

Harvey Burkholder, of Ames, died Oct. 31, 2004, at Israel Family Hospice House after a year-long struggle with ALS. Memorial services were held Nov. 3 at Collegiate Presbyterian Church in Ames.

Harvey Burkholder

Harvey Ralph Burkholder was born April 18, 1932, to Harvey and Jessie (Dayton) Burkholder in Rock Lake, N.D. After graduating from high school in Langdon, N.D., he attended college at the University of North Dakota, where he was a member of the varsity basketball team. In 1954, he married Kathryn Mott of Rolla, N.D., and they moved to Ames. He was a research chemist at the Ames Laboratory for 28 years and then worked in the analytical chemistry department at ISU until his retirement in 1997.

He was very involved locally and generously donated his time and energy to many activities. He ran the Ames Duplicate Bridge Club for 30 years and taught bridge at the Octagon and College for Seniors. He started the Ames Lab golf league and was secretary of the faculty bowling league for 33 years.

He was an active member of Collegiate Presbyterian Church for 50 years, serving as deacon, elder and trustee. Memorials may be made to CPC or the Israel Family Hospice House (c/o the Mary Greeley Foundation).

Thiel Named Institute of Physics Fellow

Pat Thiel

Pat Thiel, senior chemist, has been named a Fellow of the Institute of Physics, London, in recognition of her individual status within the physics community. This senior class of membership indicates a very high level of achievement in physics and an outstanding contribution to the profession. As a fellow, Thiel is entitled to use the designatory letters FInstP following her name.

Thiel, a Distinguished Professor of Chemistry at Iowa State University, is also a Fellow of the American Vacuum Society and a Fellow of the American Physical Society.

Donald Erbschloe, Deputy Operating Officer in the Office of Science (right), and Roxanne Purucker, manager of the Ames Laboratory Site Office, listen to Mark Grootveld, Facilities manager, during a tour of the Lab on March 14. Erbschloe was visiting the Lab in order to get a "broad brush" view of the work that goes on here. His visit was part of his plan to visit all 10 Office of Science Labs. Erbschloe plans to make biannual visits to Ames Laboratory.

First World Year of Physics Event a Success!

They had to set up extra chairs in the auditorium of the Ames Public Library as patrons filed in to see the presentation of "Physics, Sunny-side Up" by Laurent Hodges, an Iowa State University professor of physics and astronomy. The presentation on solar energy was the first in a series of special events being coordinated by Ames Laboratory's Public Affairs Office to help celebrate the 2005 World Year of Physics.

The Department of Energy is the lead federal agency for the government's observance of the World Year of Physics that marks the centennial of Albert Einstein's "miracle year," 1905, when he published papers dealing with three important ideas that have influenced the course of modern physics.

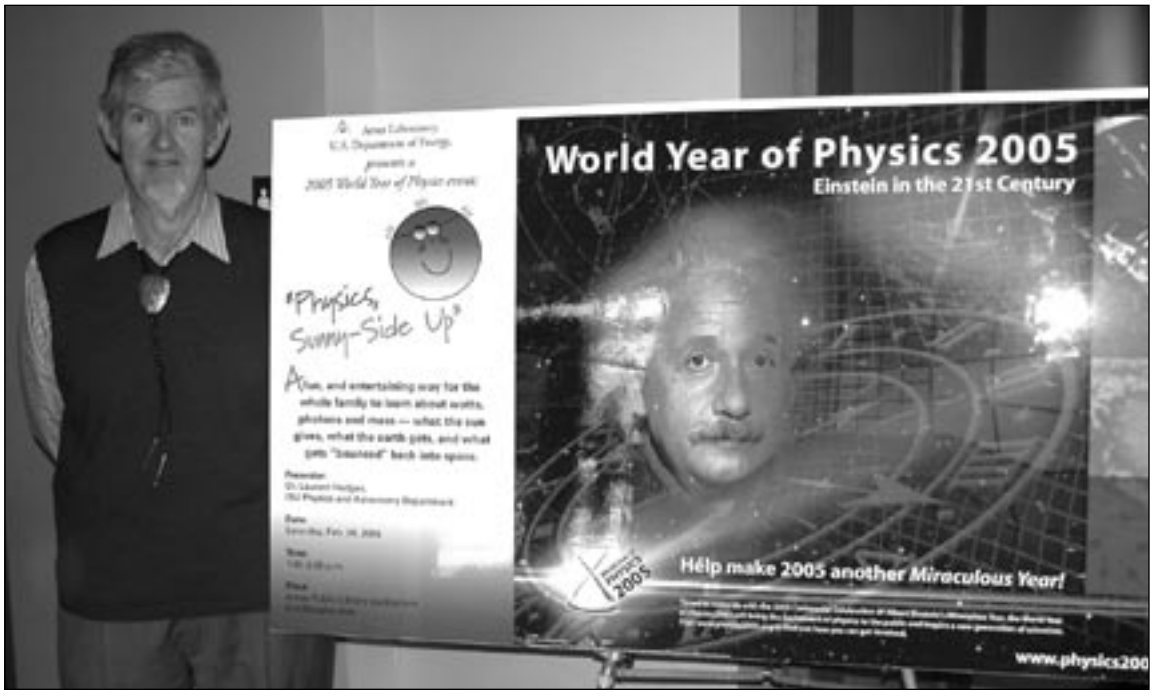
Using a PowerPoint presentation, Hodges highlighted the things solar energy does on earth, including heating the earth, providing energy for photosynthesis to produce food, driving the wind, and evaporating water from oceans and lands.

Noting that solar cells allow us to use the sun's energy for many purposes, Hodges showed pictures of his own solar home and held up his wrist so the audience could see his solar-powered watch. He had also brought along a collection of solar calculators, among them a Mickey Mouse version, which Hodges claims is his ugliest!

He went on to impress the audience with some amazing sun facts, one of which is that the sun loses 4.5 million metric tons per second in mass. Sounds like a lot, right? But maybe not for a star that is roughly 1.4 million kilometers wide. If you have a hard time picturing how big that is, think of it this way. Approximately 100 Earths could be spread across the width of the sun, and one million earths could fit into it.

More 2005 World Year of Physics events are underway. Watch for announcements in Insider and find them posted on the Ames Lab home page, *http://www.external.ameslab.gov.* ■

~ Saren Johnston



Laurent Hodges hosts the Lab's first 2005 World Year of Physics event, "Physics Sunny-side Up," at the Ames Public Library.

Beating the Heat *continued from page 1*

and, therefore, acts as a barrier against heat damage.

"By applying a thermal barrier coating to a turbine blade, it is possible to increase the combustion temperature of the engine, which leads to significantly improved efficiency in gas turbines," says Dan Sordelet, an Ames Laboratory senior scientist. He explains the ability of the bond coat to oxidize and form a continuous, slow-growing and adherent TGO layer is critical to creating a resilient and reliable thermal barrier coating.

Things can and do go wrong

Sordelet emphasized that cracking or breaking apart of the TGO layer due to time and service in a severe environment is one of the main causes of failure in a TBC system and the associated engine components. Also, at temperatures around 1100 degrees Celsius (2012 degrees Fahrenheit) and above, the aluminum in the bond coat begins to diffuse more rapidly into the substrate, changing the overall bond coat composition.

"If enough aluminum diffuses into the substrate, eventually a phase change, which is a change in the crystal structure, occurs and can lead to large-scale distortion of the bond coat surface and subsequent failure of the TBC system," said Sordelet. Elaborating, he added, "Initially, there is a very thin TGO layer sitting on a very flat bond coat surface. If the bond coat continues to lose aluminum so that phase transformations take place, conditions will change from thin and flat to thin and 'rumpled.' Stresses develop, and the likelihood for the top coat to come off increases rapidly."

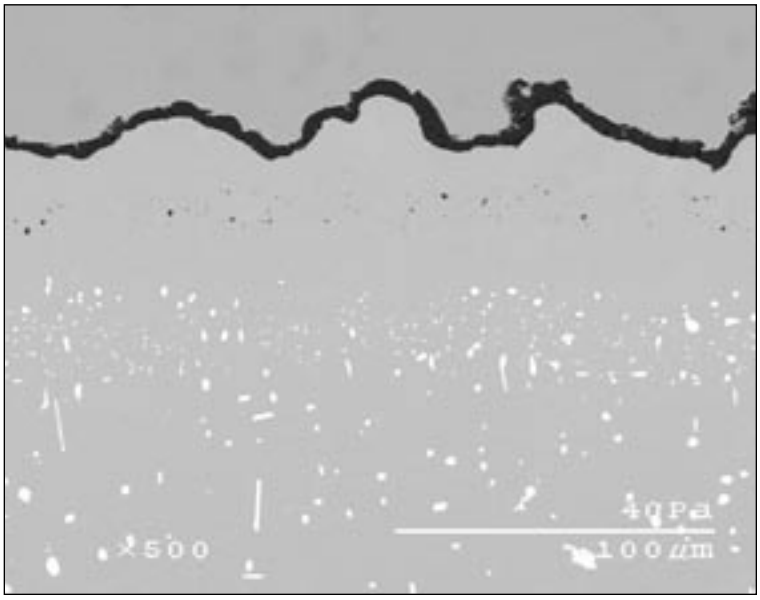
Understanding the alloy – the platinum bonus

Working to improve the reliability of TBC systems, Sordelet and Brian Gleeson, director of Ames Laboratory's Materials and Engineering Physics Program and an ISU professor of materials science and engineering, have performed experiments on various nickel-aluminum-platinum, or Ni-Al-Pt, alloy samples made by Ames Laboratory's world-renowned Materials Preparation Center.

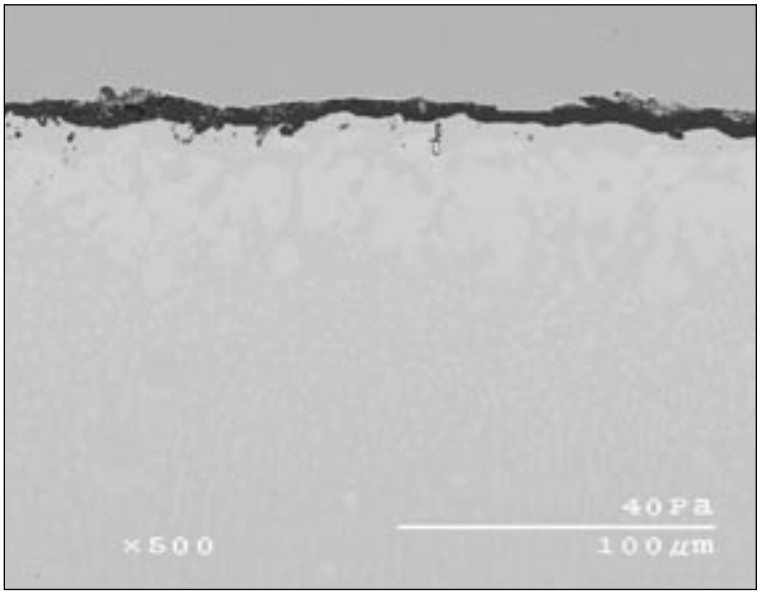
"Dan and I received funding from the Office of Naval Research to conduct fundamental research on the Ni-Al-Pt system, including experimental determination of isothermal phase diagrams," said Gleeson. "The phase diagrams provided much-needed guidance for elucidating the relationships between phase constitution/composition and properties in this system."

Quite unexpectedly, the two researchers found that platinum additions significantly improved the oxidation resistance of nickel-rich bulk alloys having the same type of structure as the turbine alloy. Without platinum, these alloys form a relatively fast-growing TGO scale that is prone to spall, or break up, during thermal cycling. By adding platinum, the alloys become highly resistant to oxidation, forming a tenacious, slow-growing TGO scale. But Sordelet and Gleeson weren't satisfied yet.

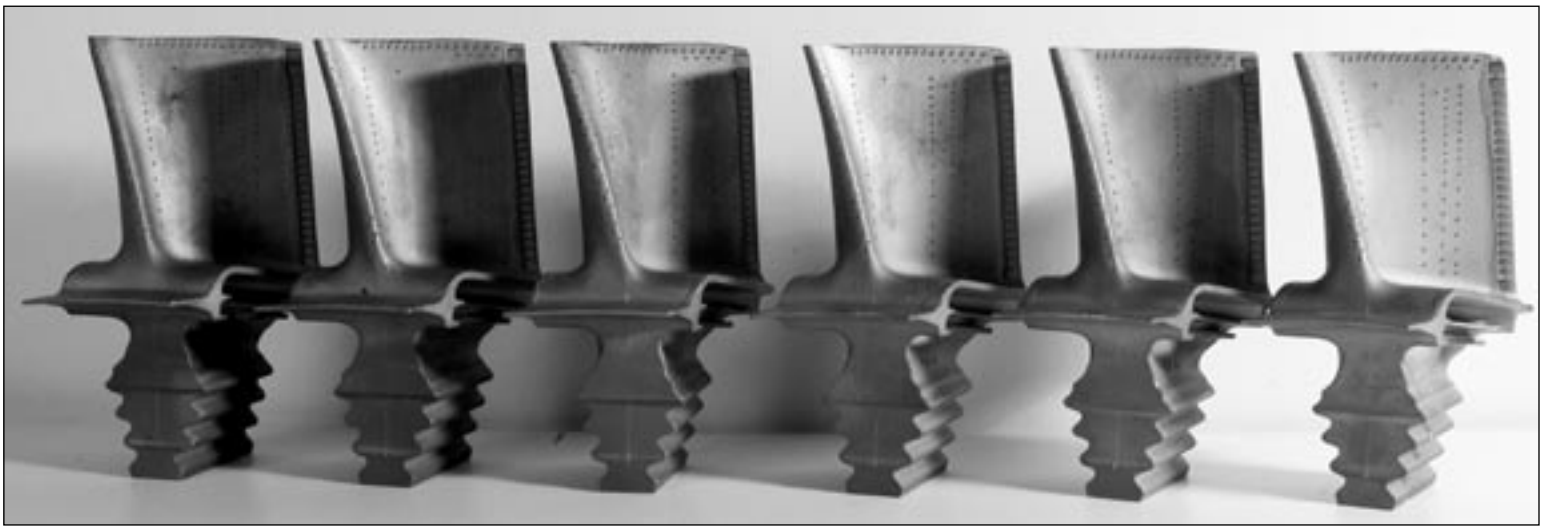
A unique bond coat composition developed by Dan Sordelet (left) and Brian Gleeson may one day become the standard in thermal barrier coatings that protect gas turbine blades, like the ones they're holding, from heat damage.



This electron microscope image of a commercial bond coat after thermal cycling shows how the thermally grown oxide becomes "rumpled," leading to subsequent spallation of the ceramic top coat and failure of the entire TBC system.



This electron microscope image of the new Ames Lab/ISU bond coat composition after the same number of thermal cycles shows essentially the same surface topography as the starting surface (i.e., no "rumpling").



Sordelet and Gleeson's new bond coat for thermal barrier coating systems will allow higher operating efficiencies for gas turbine blades in aircraft engines.

A little dab will do

"In the typical design of alloys for oxidation resistance, you always find that adding a little sprinkle of this and a little sprinkle of that can have dramatic effects," said Sordelet. "Well, Brian's intuition to sprinkle either zirconium or hafnium was remarkably accurate." As the researchers added a little bit of either or both to the nickel-rich compositions, things improved tremendously.

"With the addition of hafnium, oxidation rates went down by up to an order of magnitude," Sordelet said. "We now have growth rates that are the lowest ever reported. It's quite remarkable!"

In current aluminum-rich bond coat alloys, only a very small amount (e.g., < 0.1 wt.%) of zirconium or hafnium may be added to improve oxidation before adding too much is detrimental, causing catastrophic oxidation failure. In commercial coating production, it is extremely difficult to achieve an adequately uniform distribution of such a small amount of metals like these in a cost-effective way.

"Fortunately, in the new nickel-rich bond coat, we have observed significant reductions in oxidation rates over a wide concentration, from 0.5 to 4 wt.% hafnium," Gleeson emphasized. "These are no longer 'trace' levels to a processing engineer and can thus be easily alloyed homogeneously throughout the material." This attribute gives Sordelet and Gleeson's new coating a huge processing window, which they both say has been very desirable to people they've visited with in the coatings industry.

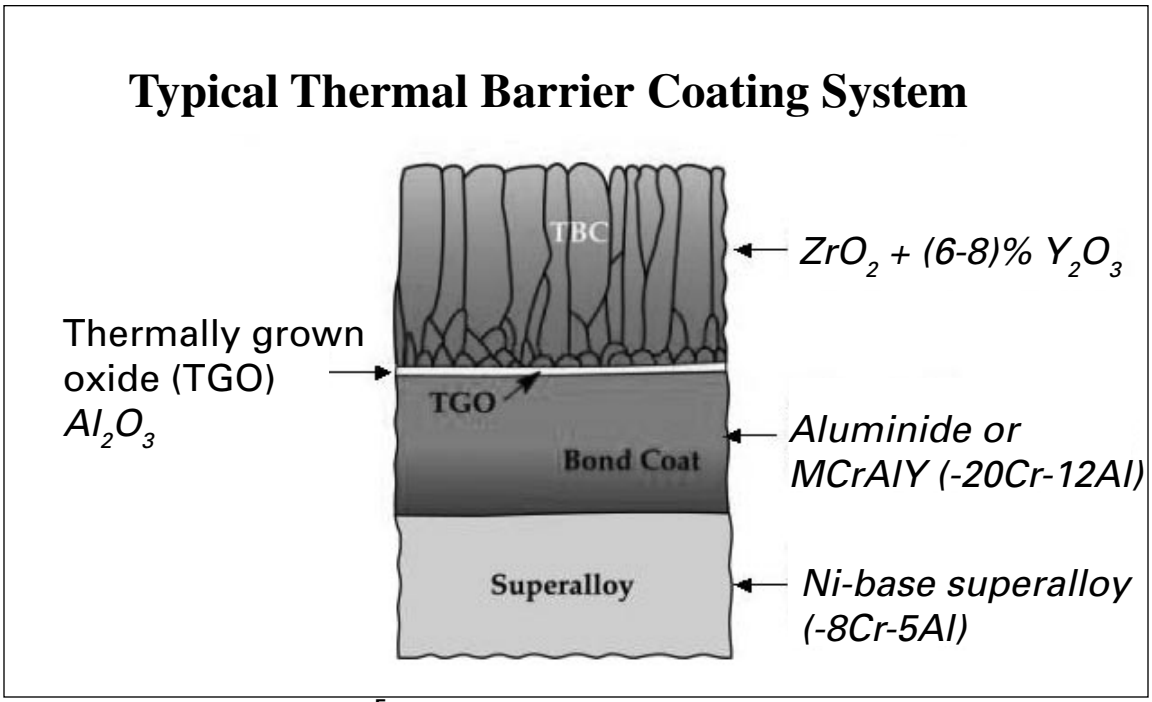
Bulk Luck

Their work with the bulk alloys led Gleeson and Sordelet to yet another fortunate result. They discovered that platinum changed the diffusion behavior of aluminum in their nickel-rich compositions.

"Instead of aluminum going from the bond coat down into the substrate, it was moving up from the substrate into the bond coat," explained Gleeson. "This phenomenon is referred to as 'uphill diffusion,' and it's a consequence of the strong chemical interaction between aluminum and platinum. With our new bond coating compositions, the substrate can act as a large reservoir for aluminum and hence maintain the protective growth of the oxide layer."

The two researchers have recently demonstrated their new coatings can offer significant benefits over current state-of-the-art bond coatings used in advanced TBC systems. "We have been working with an aeroengine manufacturer, and the results to date have been extremely encouraging," said Sordelet. ■

~ Saren Johnston



Ottumwa middle schoolers take Science Bowl training seriously

From imploding pop cans to dissecting pig hearts, 17 students from Ottumwa's Evans Middle School are learning whatever they can in preparation for the annual Ames Laboratory/ Iowa State University Regional Middle School Science Bowl competition. The top five students and their coach, Sue Happel, will be among 16 teams expected to participate in the event at Iowa State University, April 8 and 9.

To say that Happel's students are taking the competition seriously is an understatement. Interested students and their parents met in December to learn about Happel's rigorous, 14-week Science Bowl training program. The training began in January with 19 students, and by the end of the month, two students had left the program.

The students meet once a week for two hours to perform hands-on experiments and bone up on topics based on last year's practice questions. The topics consist of mathematics, physics, chemistry, geology, astronomy and biology. The students are strongest in mathematics, physics and chemistry, says Happel, a Talented and Gifted Program teacher at Evans Middle School.

Ottumwa pediatrician, Grant Mellor, is assisting Happel in preparing the students for the Science Bowl competition. Mellor, a former high school chemistry and physics teacher, had a son on the 2004 Science Bowl team. In addition to his time, he has volunteered a room in his basement as a classroom and provided the students with supplies.

According to Happel, the hands-on experiments are the highlight of the training program, especially dissecting pig hearts and eyeballs. Mellor, who is also an accomplished guitarist, composed a song to help the students remember the parts of the eye and their functions.

Evans Middle School (Ottumwa) students Jennifer Alspaugh and Andrew Kaake discover the inner workings of a pig's heart during a dissection exercise. (below) Eric Buller, left, prepares a pop can for implosion as Ottumwa pediatrician and science training volunteer Grant Mellor looks on. Mellor volunteered his time, his home and supplies to help Evans Middle School coach Sue Happel get students ready for the Science Bowl competition.

The students also enjoy staging practice competitions using old and new practice questions. Besides the regular quiz competitions, the students held a contest to pick their team name, the "Accelerators."

Beyond the lessons and experiments in class, students receive homework assignments that involve reading and writing on science topics as well as lab reports. Parents must sign their homework each week.

Amidst all the required paperwork, the teachers have fun learning with the students. The teachers have to keep up with checking homework and keeping attendance records, as well as evaluating participation, teamwork and sportsmanship. All of these components will be used to determine which students make the team that will compete at ISU. ■

~ Eric Barada

AHS team brushing up for National Science Bowl

Practice match pits students against faculty

The young man shifts his steely eyes to the window, and a momentary cloud of suspense silences the room. "X," he finally answers. That is... correct! Everyone collectively exhales and the room fills with cheers. The feeling is euphoric.

Although a recent practice match against faculty members may have lacked that level of drama, Ames High School's Science Bowl team hopes that euphoria describes their experience when they travel to Washington, D.C. April 28 - May 2 to compete in the National Science Bowl. The group of four juniors and one senior won the Ames Laboratory/ISU Regional Science Bowl competition in January to earn the right to advance to the National Science Bowl, sponsored by the U.S. Department of Energy.

"We aren't just in it for a trip, we are in it to advance to the finals," explains AHS coach Kirk Daddow of the team's preparation. For starters, each of the five students is studying his favorite subject for the competition. Neal Marasinghe is studying biology. Chuck Cleary and Joshua Moloney are concentrating on physics. Xin Pan is covering both physics and chemistry and Dave Gan is taking the lead in mathematics.

To test their knowledge of the subject matter, the students squared off in a practice match on March 24 against five Ames High School science and math faculty members. Both students and teachers amazed the audience throughout the match by correctly answering questions before they were completely read.

Competition in the two-game match was close. The faculty dominated the first game and the students won the second, requiring a three-question tiebreaker to determine the winner. The teachers answered the final question correctly to triumph over the students. Even with the loss, the students were upbeat.

"We are excited for the national competition," says Marasinghe, the lone senior on the team. "The regional competition was our best performance ever," a performance on which they hope to build.

The DOE awards an all-expenses paid trip to the National Science Bowl to each of the 66 regional Science Bowl winners. In addition to competing in the academic competition, students will see the Washington sights and hear presentations on current science topics. ■

~ Eric Barada
Photos ~ Shauna Stephenson

AHS science faculty members (left) help the AHS Science Bowl team practice for the upcoming National competition by holding a practice match on March 24.

Teacher Jeff Dilki laughs at an answer.

AHS Science Bowl coach and practice session moderator Kirk Daddow (right) waits for the faculty team to come up with an answer to a toss-up question.

AHS Science Bowl team captain Neal Marasinghe (left) searches hard for the answer to a question while teammate Xin Pan looks on.

Wine 'em and Dine 'em

Bartons host second (annual?) wine-tasting party

Was it worth the $300 price tag it brought at the Holiday Auction? Well, you'd have to ask the guests who attended Tom and Betty Barton's wine-tasting party in February, but chances are you'd probably get a unanimous "yes."

The event, dubbed "Wine Tasting on a Winter's Evening," has been offered up for bid at the last two Holiday Auctions by Deb Covey, Ila Haugen and Saren Johnston to help raise funds for local charities. Director Tom Barton had the top bid both times, but in 2004, WTWE cost him nearly double what he paid in 2003!

Still a bargain at $300, the party includes six different wines, prizes for guessing the correct prices of the wines, and cheesecake to top off the evening, not to mention the four hours of steadily increasing fun and laughter with the presentation and sampling of each wine.

This year's WTWE was tremendously enhanced once again by Betty Barton, who set a fabulous table filled with cheeses, fruits, crackers, nuts, and many other tempting goodies. Other "enhancements" included four extra bottles of wine donated by Tom Barton and Bruce Harmon.

The Bartons' guest list included Deb and Jerry Amenson, Glenice and Tom Wessels, Bonnie and Bruce Harmon, and Fran and Cal Dunshee.

Including the Bartons, there were ten partygoers and ten bottles of wine – you do the math – so this year's WTWE was a good time! ■

~ Saren Johnston

Clockwise from top:

Physicist with new camera and patient wife. Enough said.

The ambiance. Ah … the elegance of the table before the onslaught of the guests! With at least half a dozen wine glasses at each place setting, Tom and Betty Barton are ready for WTWE.

Cleansing the palette. Deb Amenson prepares her tastebuds for another of the evening's wines.

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Editor Saren Johnston
Layout Kerry Gibson

Address comments to:
Editor, ***INSIDER***
111 TASF
Ames, IA 50011-3020
515/294-9557
FAX 515/294-3226

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